TESTIMONY BEFORE THE SUBCOMMITTEE ON TRANSPORTATION, HOUSING AND URBAN DEVELOPMENT, AND RELATED AGENCIES, COMMITTEE ON APPROPRIATIONS

Hearing on the Climate Resiliency Within the Transportation Industry

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Chairman Schatz, Ranking Member Collins and Members of the Subcommittee on Transportation, Housing and Urban Development, and Related Agencies. My name is Habib Dagher and I am the Executive Director of the University of Maine's Advanced Structures and Composites Center (ASCC). It is the largest university-based research center in Maine, with 260 full and part-time employees[1]. Over 35 years at UMaine, I have dedicated my life to develop technologies that create jobs and protect the environment. We conduct research on the development of sustainable advanced materials, structures, and construction methods suitable for transportation, housing, and defense applications. Our work on innovative construction materials has earned national and international recognition, including the White House Transportation Champion of Change.

The Center through our research grants and contracts has financially sponsored 2,600 student interns, who got paid to work on research projects. This R&D experience transforms their education and prepares them to become leaders in the field. I also lead the newly established US DOT Region 1 University Transportation Center, called the Transportation Infrastructure Durability Center (TIDC). TIDC is currently conducting over 40 research projects across Maine and New England, all aimed at increasing the life of our transportation assets, and developing designs for more durable, sustainable and resilient roads, bridges and port facilities. These research projects are enabled by the US DOT UTC program. Each project has a designated State DOT "Champion", who insures that the research innovations are put into practice within state DOTs and industry.

As you will see from the four examples that I will provide, investment in research and development (R&D) such as the UTCs, are key to achieving a cost-effective, resilient transportation system of the future. We can't keep building it the same way and expect a different result. As we rebuild our roads and bridges, we have a once-in-a-lifetime opportunity to use more durable, more sustainable advanced materials including composite materials. That's exactly what the *IMAGINE Act* introduced by Senators Collins and Whitehouse in March would facilitate. It would fund research into new materials and building techniques, and would spur federal investment in infrastructure projects that utilize innovative materials, focusing on more durable coastal and rural assets. The *IMAGINE Act* will be critical to maintaining U.S. technological leadership in the advanced materials space, and the stakes are very high. New construction is expected to be worth $1.5 trillion in the U.S. in 2022, and the construction industry is worth more than 10% of the world GDP.

The following are examples of four composites materials projects that we have carried out at UMaine, which help achieve a more resilient transportation infrastructure: 1) The "bridge in a backpack" composites arch technology; 2) The Composite tub U-Girder technology; 3) Floating deployable breakwaters; and 4) Bio-based 3D printed culvert diffusers to protect roads from storms.

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[1] https://composites.umaine.edu/

1. **The "bridge in a backpack" composites arch technology**. Highway bridges are built by inflating lightweight composite arches that can fit in a hockey bag and can be picked up by one person. The tube is inflated, it is bent to an arch form over a mold, infused with a resin, and four hours later, one has a hollow tubular arch that is stronger than steel. The lightweight arches are placed 5 or 6 ft apart, a composite material corrugated deck is lag screwed over the arches, the arches are filled with concrete, the bridge is backfilled with sand and paved. These bridges have been commercialized and a company in Maine is kitting them and sending them across country. Because they are lightweight, the kits can be easily transported to the site after a natural disaster, and do not need heavy equipment to build. They require little maintenance and are designed for a 100 year life. Their carbon footprint is about ½ of that of a conventional bridge.

Figure 1 - Used in more than 30 bridges, the patented "bridge-in-a-backpack" technology reduces life cycle costs, reduces carbon footprint by approximately 50%, accelerates bridge construction and is AASHTO approved. Arches are lightweight and can be produced near the bridge site, which makes them suitable for disaster response. A 60 ft 2-lane bridge kit can fit on a pickup truck or in a 20 ft shipping container.

2. **The Composite U-Girder Technology**. These U-shaped composite “tub” girders are very light, $1/3^{d}$-1/4 the weight of steel girders. One can transport the girders for four 2-lane, 70ft long bridges, on one stretch-bed. The girders are designed for 100 years, and they nest together reducing the shipping volume. The concrete deck is designed to be removable so that jack-hammering of the deck after 50 years is not needed. The carbon foot print is reduced due to the efficient shipping, use of small cranes, and the increased 100 years life.

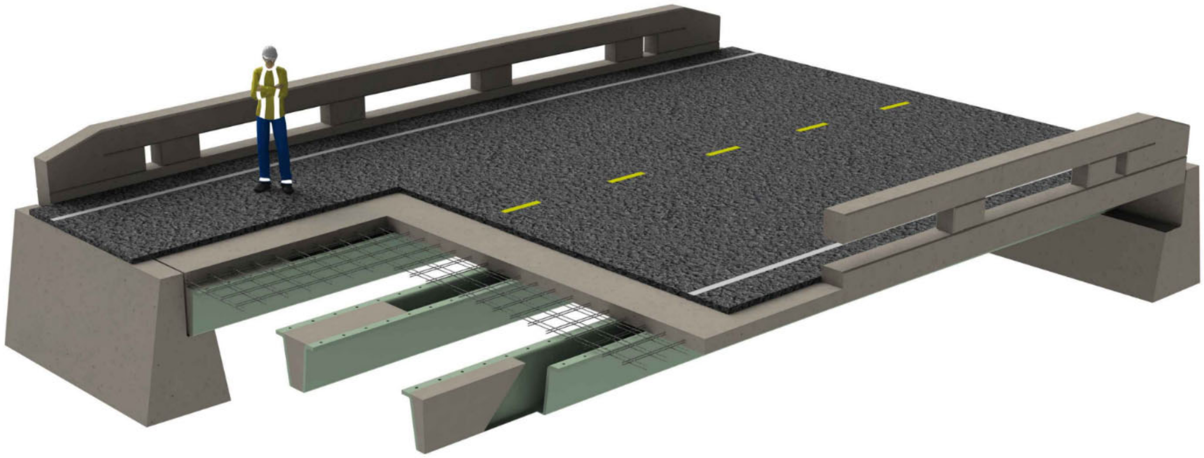

Figure 2 - The lightweight tub U-Girders are designed for 100 years, and support a concrete deck that can be “unbolted” and replaced after 50 years, eliminating the need to Jack-hammer the deck.

16 U-Girders for 4 bridges
Fit on one stretchbed = 42,496 lb.

16 steel girders for 4 bridges
need four stretchbeds = 151,200 lb.

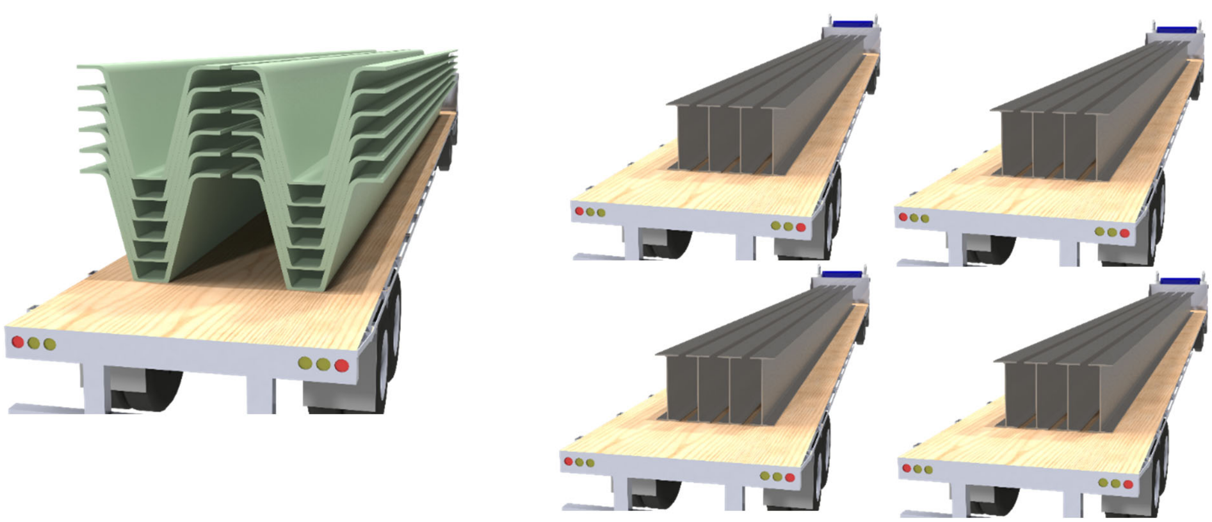

Figure 3 - Four 70ft long U- girder bridges fit on one truck. The heavier steel girders require 4 trucks.

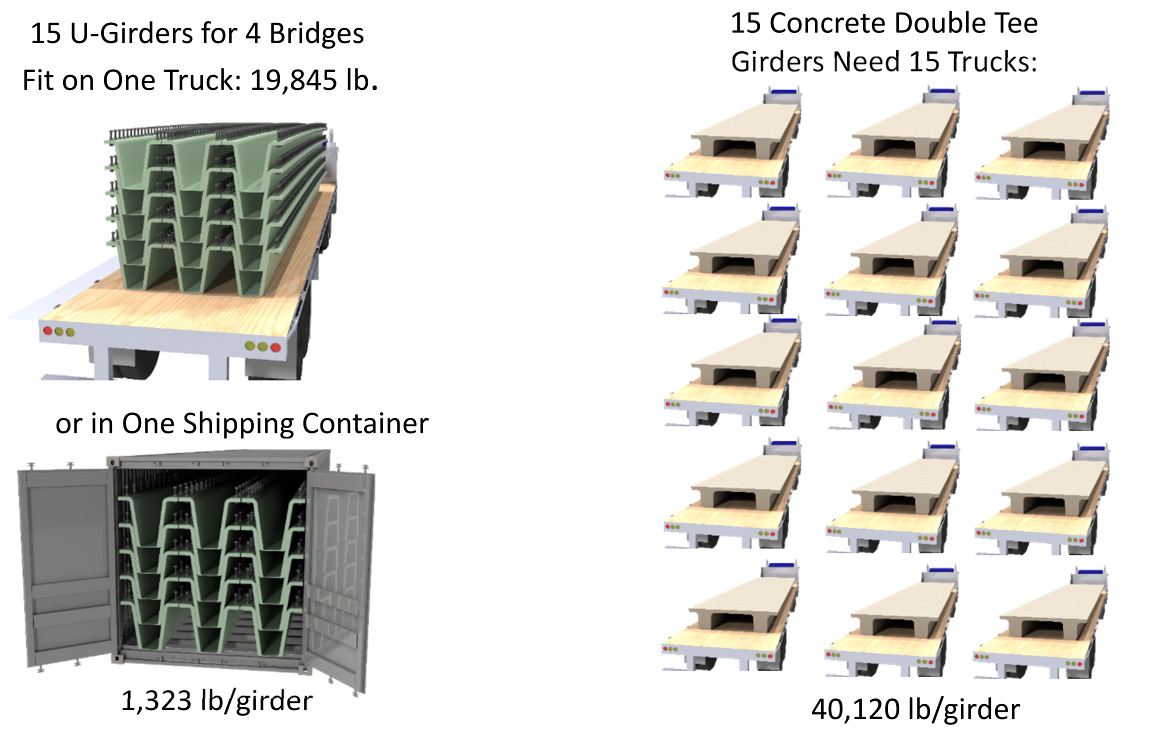

Figure 4 - Four 40ft U-girder bridges fit on one truck. The heavier concrete girders require 15 trucks.

Figure 5 - 3D printed U-girder mold made on the world's largest 3D printer at UMaine.

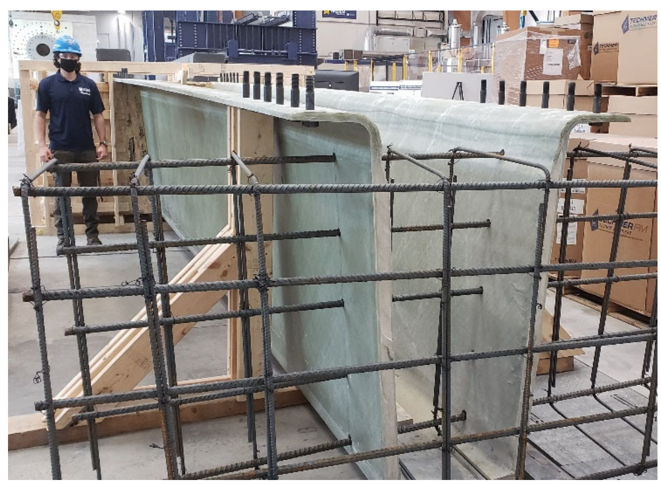

Figure 6 - Composite U-girder made on the 3D printed mold.

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Novel Fiberglass Girders Extend Life of Maine Bridge

Composite tub girders with no concrete reinforcement are also being designed for bridges in Rhode Island and Florida

The Grist Mill Bridge, a 75-ft single span bridge in Hampden Maine, is the first in the nation to use composite tub girders with no concrete reinforcement in the superstructure. Photo courtesy of Advanced Infrastructure Technologies

Figure 7 - Grist Mill bridge article in ENR, Jan 25, 2021

https://www.enr.com/articles/51086-novel-fiberglass-girders-extend-life-of-maine-bridge

3. Modular deployable floating breakwater designs to protect coastal assets

- Floating breakwater deployed before a storm arrives to protect coastal assets or coastal operations, removed afterwards
- Self-adjust to water level
- Modular design, easily stored, then assembled for rapid deployment when needed
- The breakwater technology can help reduce coastal erosion using bio-based 3d printed materials.
- This year, a 75 ft prototype breakwater will be deployed offshore Maine to test the ability to reduce sea-state 2 incident wave energy by 40-50%,

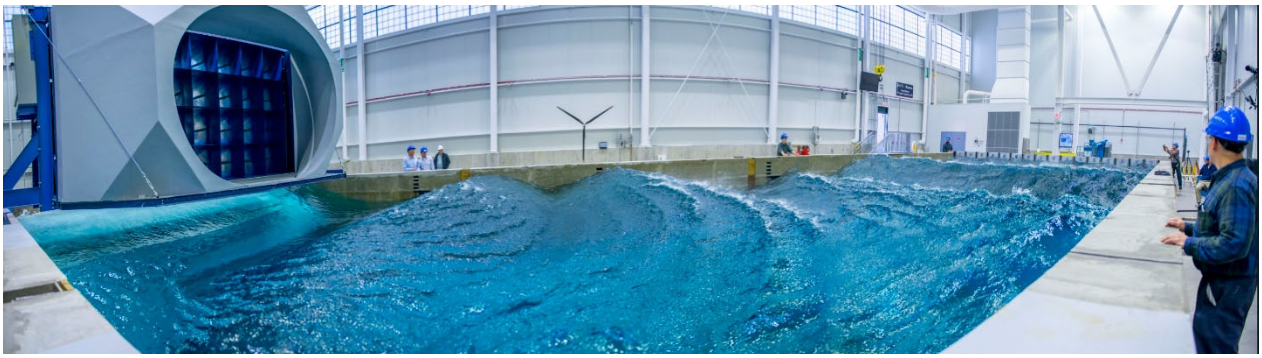

Figure 8 - UMaine W2 Wave-Wind ocean engineering lab where the floating breakwaters were tested.

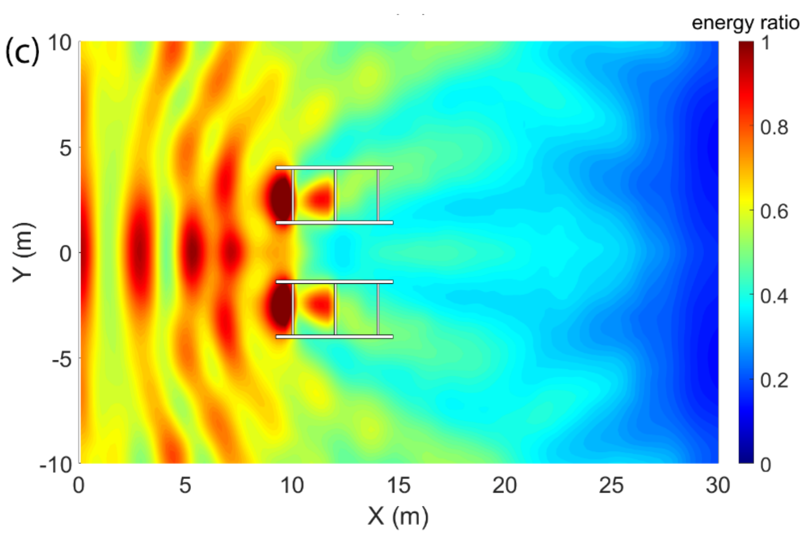

Figure 9 - Effectiveness of floating breakwater in reducing wave energy

Figure 10 - Floating breakwater test site off the Maine coast later this year.

4. **Bio-based 3D printed culvert diffusers to reduce roadway storm damage**

- When corroded culverts are re-lined, the flow is restricted.
- Culvert diffusers can increase the flow by 40%, mitigating roads washing-out after storms.
- Large scale 3D printing technology enables rapid manufacturing of complex shaped culvert diffusers at half the cost, using bio-based materials.
- Increasing the drainage flow in culvert relining projects by 40%, avoids millions of dollars spent in complete culvert bridge replacements.
- First 3D-printed culvert diffuser to be installed in Maine this summer.

Figure 11 - 3D printing the culvert diffuser using biomaterials at UMaine ASCC

Water in

Water out

Diffuser increases water flow by 40%, mitigating flooding and roadways washing out

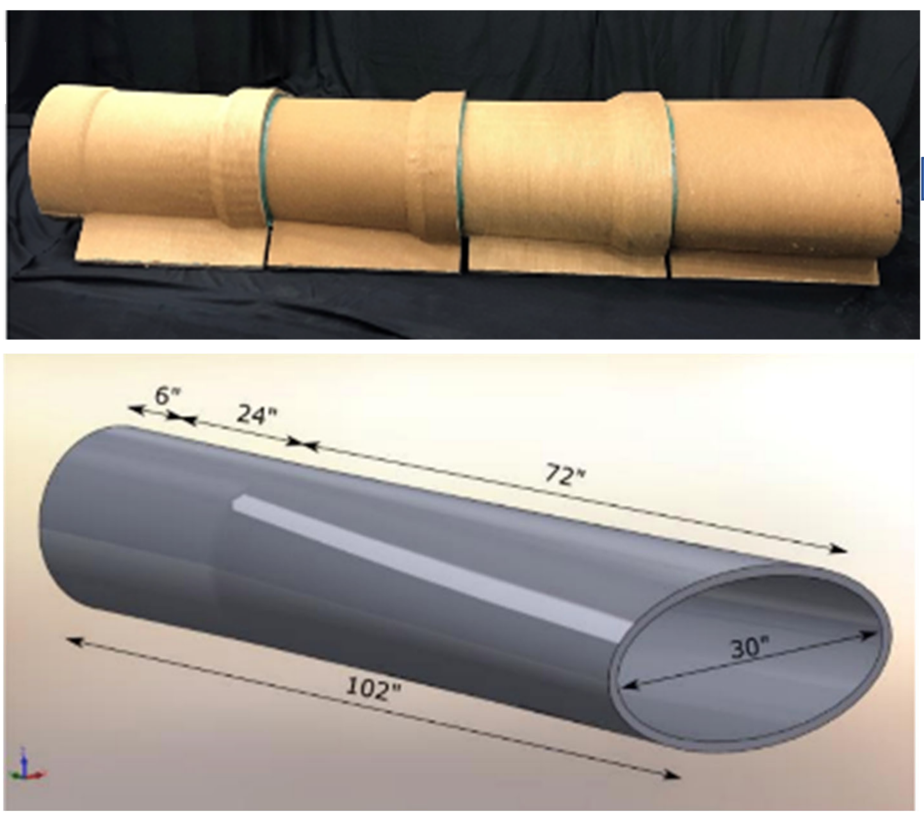

Figure 12 - 6 ft long printed culvert diffuser will be installed by the Maine DOT this summer to test protection against flooding.